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REVIEW

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Fresh whole blood: A feasible alternative in disasters and mass casualty incidents? a systematic review and meta-analysis

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Abstract

Introduction While balanced blood component therapy (BCT) is pivotal in trauma patient damage control resuscitation in well-resourced settings, disasters, and mass casualty incidents (MCIs) pose significant challenges, especially in securing sufficient access to blood products. This systematic review and meta-analysis aim to explore the utilization of fresh whole blood (FWB) transfusion as a potential alternative to BCT, informing future research and clinical strategies.

Methods We searched Pubmed, MEDLINE, Embase, CINAHL, the Cochrane Library and grey literature for articles identifying FWB transfusions, limited to those published in English or French. We evaluated the outcomes of post-FWB transfusion and conducted a meta-analysis comparing overall mortality in patients receiving FWB in addition to BCT during damage control resuscitation with those receiving BCT or single blood components alone.

Results Of the 4830 studies identified, only 74 articles met all the eligibility criteria; the majority of them were conducted in military contexts. Mortality was lower among the FWB group compared to the BCT alone group, with a pooled OR of 0.61 (95% CI: 0.38—0.98) overall, and a pooled OR of 0.47 (95% CI: 0.25—0.87) among studies adjusting for confounders. FWB transfusion related complications rarely occurred.

Conclusions While FWB shows potential as an alternative to BCT for managing severe haemorrhagic shock in disasters and MCIs, additional research is essential to validate FWB's efficacy before considering it as a standard approach in civilian scenarios. Further studies focusing on the feasibility of implementing FWB in civilian contexts are also warranted.

Keywords Fresh whole blood, Walking blood banks, Mass casualty incidents, Disasters, Damage control resuscitation\

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Introduction

Inadequate management of bleeding has been identified as a leading cause of potentially preventable deaths among trauma patients [1]. Damage control resuscitation using blood product replacement, in addition to damage control surgery, represents the cornerstone for the treatment of acute life-threatening haemorrhages [2]. Specifically, a growing body of evidence consistently endorsed the idea of a balanced blood component therapy (BCT) for achieving haemostasis through the transfusion of packed red blood cells (pRBCs), fresh frozen plasma (FFP), and platelets (PLT) in a 1:1:1 ratio, thus closely approximating whole blood (WB) [3–5]. In resource-rich contexts, the accessibility of transfusion services and the provision of balanced BCT products are usually granted. Nevertheless, this is not always true in scenarios with a sudden surge in demand for blood products, such as disasters, conflicts, and mass casualty incidents (MCIs), especially those linked to terrorism [1, 6, 7]. For instance, during the terrorist bombings that occurred between 2000 and 2005 in Israel, almost 40% of the victims required blood transfusions, 10% of whom needed massive transfusion [8]. Similarly, in the terrorist attacks of Paris in 2015, 20% of the 337 victims received blood, most of them, in the first two hours [9]. Since damage control resuscitation of multiple patients can easily deplete blood stocks at a single hospital, understanding the utilization patterns of blood in MCIs and disaster settings is crucial for medical resource planning. For instance, the aftermath of the hurricane Katrina, (New Orleans, USA, 2011) led to the recognition of the need to improve the U.S. domestic blood management system [10]. Additionally, this aspect becomes particularly relevant in countries without integrated health systems, where the availability of such a service cannot be guaranteed, to the extent that the new term "blood deserts" has emerged [11]. A World Health Organization (WHO) study in the Middle East region revealed that half of the 22 included countries reported weaknesses in their national emergency plans, including blood product management and blood donor mobilization [12]. Accordingly, the Blood Delivery via Emerging Strategies for Emergency Remote Transfusion (Blood DESERT) Coalition has recently highlighted an annual deficit of 102 million blood units in low- and middle-income countries [11].

Of note, even when disasters and MCIs do not generate an immediate demand for blood, they could easily disrupt the delivery process. Factors contributing to this disruption, particularly in developing countries, can manifest at various levels within the health infrastructure. These include challenges related to transportation and storage arising from adverse weather conditions, security constraints, and the direct impact of disasters on the health facilities [8, 9]. Therefore, since both small and large hospitals must be prepared for quick blood collection, distribution and administration, blood product management is crucial for disaster planning. In this context, fresh whole blood (FWB) could be a feasible and rapidly available alternative to BCT for life-threatening haemorrhages in MCIs [13–16]. The prevailing definition of FWB describes blood collected by a donor, that remains viable at room temperature for up to 24 h after collection [17]. FWB can be refrigerated within 8 h from collection thus transitioning into stored whole blood (SWB), which can be stored up to 35 days maintaining an acceptable haemostatic function; however, patients may require supplementation with specific blood components or coagulation factors [17]. The notable advantages of FWB vs SWB can be attributed to the optimal 1:1:1 ratio of unaltered blood components (maintained in right proportion and temperature) along with a lower amount of conservative products, and the absence of a stringent cold chain requirement [16, 17]. Of note, damage control resuscitation with FWB transfusion was extensively used in the battlefield from World War I (WWI) until the discovery of the human immunodeficiency virus (HIV) in the 1980's [15, 16].

In the last decade, there has been a renewed interest in employing FWB during combat operations [13], potentially driven by field [17] and anecdotal reports of improvement in certain patients [18, 19] and facilitated by the introduction of rapid immunochromatographic screening test for HIV, HCV and HBV [16]. Indeed, during the conflicts in Iraq and Afghanistan, more than 6000 units of FWB were administered to casualties experiencing severe haemorrhage [17, 20]. However, the prevalent practice, even in these specific contexts, prioritized the use of BCT whenever available [20]. Moreover, in the absence of published prospective randomized trials examining the benefit of balanced BCT over FWB, current guidelines for blood transfusion recommend starting with restricted fluid resuscitation, followed by blood products and coagulation factors [1]. However, available guidelines do not address the specific contexts of disasters, conflicts, or MCI settings [1]. Additionally, evidence on the current utilization of FWB seems to be scant and disperse, thus preventing a deeper understanding of potential indications, risks, and outcomes of civilians. The aim of this paper is therefore, to conduct a systematic review and a meta-analysis on the outcomes after FWB transfusion, identify current gaps and provide recommendation for future studies.

Methods

This study was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist and PRISMA-P 2020 guidelines [21]. The study protocol was registered in the International Prospective Register of Systematic Reviews (PROSPERO, ID = CRD42020171851).

Article selection

Electronic databases including Pubmed, MEDLINE, Embase, CINAHL and the Cochrane Library were searched, as well as other sources of grey literature such as the websites of The World Health Organization, Centers for Disease Control and Prevention and Food and Drug Administration. Websites and/or internal documents made available by medical organizations known to use FWB (such as Médecins Sans Frontières, Emergency, International Committee of the Red Cross) were also screened for inclusion. The search was conducted in December 2023. Search terms included "fresh whole blood" OR "fresh, whole blood" OR "fresh blood" in the title or abstract. To ensure literature saturation, the reference sections of the retrieved studies were manually inspected to obtain additional titles. Standardized pilot tests for screening and data entry were also conducted before the search.

Three authors, MB, GM and LP, independently screened the titles, abstracts and full texts of all papers to exclude those not relevant to the objective of the review and extracted data using a predefined data extraction template. Any disagreements were resolved by discussion. Two further reviewers, DC and MR also double-checked the results of the first research. During a final round, a senior researcher, ARG or MC, checked the accuracy of the data entered. The following criteria were used to identify duplicates and overlapping or companion studies: author name, setting, interventions performed, sample size and type of participants and date and duration of the study. Attempts to receive additional information from the authors of the retrieved articles were limited to a maximum of three.

Eligibility criteria

Considering the scarcity of pertinent evidence expected on the topic of FWB transfusion, any qualitative or quantitative study written in English or French reporting on the utilization/associated risks/outcomes of transfusion with FWB was included regardless of aim, design, and patient type. In addition, articles covering a broader and/or personal perspective of the topic (e.g., commentaries, letters, or editorials on the author's personal experience with FWB transfusion) were also included. No additional search limits were imposed. Papers were excluded if they were basic research studies or reported on the use of autologous FWB transfusion, defined as the reintroduction of blood or its components back into the same individual from whom they were initially drawn. Additionally, papers were excluded if they reported the use of WB without specifying whether it was FWB or SWB. Exclusion criteria also encompassed the utilization of FWB in non-human subjects, as well as papers exclusively focusing on methods or analysis of FWB collection. Furthermore, studies that primarily examined the use of fresh blood as a diagnostic tool, or where FWB was not administered intravenously or within the context of an emergency, were also excluded.

Data extraction

The following study characteristics were extracted: study title, publication year, journal, country where the study was conducted, language, type of research (quantitative vs qualitative), study design (review, descriptive studies, and analytical studies), sample size, mean participant age, study population (e.g., acute haemorrhagic or planned elective surgery) and discipline (e.g., trauma, or sepsis), control intervention (e.g., pRBC, BCT), test for fresh blood screening, study setting (military vs civilian) and sub-setting (pre-hospital vs in-hospital) data source (hospital records or ad hoc databases) and outcome/s. For each outcome, we extracted the outcome description (e.g., mortality) and, when applicable, the follow-up time.

Data synthesis and statistical methods

We conducted a random-effects meta-analysis of studies comparing overall mortality, during damage control resuscitation, in patients treated with FWB in addition to BCT and patients receiving BCT or single blood components alone. In order to evaluate the robustness of the results of the main analysis, we also conducted different secondary analyses. Occasionally, we provisionally restricted the analysis to the following subgroups: studies adjusting by possible confounders, studies using propensity score methods to balance differences between groups, studies using balanced BCT as the control therapy, studies evaluating early mortality (first 24 h) and studies evaluating late mortality (more than 24 h). All tests were two-sided and performed at the 5% level of statistical significance. We assessed heterogeneity among studies using I2 statistic, which was categorized as either small (from 25 to < 50%), medium (from 50 to < 75%) or large (> 75%). Publication bias was evaluated examining the funnel plots. Statistical analysis was performed using Stata software version 14 (StataCorp).

Results

Study characteristics

The literature search yielded a total of 7215 references. After excluding duplicates, 4830 papers were selected for further screening. A total of 4570 titles and abstracts were removed according to the inclusion and exclusion criteria (Fig. 1).

Six full texts were unretrievable. Ultimately, 74 studies were included (Supplementary Table 1). All the included studies were published between 1974 and 2021 and most (47/74—63.5%) were published between 2011 and 2020. Out of these, only 28 were original research studies (37.8%) while the remaining consisted of reviews (29/74—39.2%), case reports (12/74—16.2%) or commentaries (5/74—6.8%). Among original research studies, observational retrospective cohort were the most common subtype (14/28—50%). The outcomes reported in original studies were mortality (16/28—57.1%), transfusion related complications (10/28—35.7%) and the amount of FWB transfused (5/28—17.9%). Overall, the study population was mainly composed of acute haemorrhagic patients (66/74—89%), while it was not defined for 5/74 (6.8%) studies. Most of the included studies were set in a military environment (57/74—77.0%). Additionally, most studies reported the transfusion of FWB within the hospital setting (50/74—67.6%). In the majority of cases where the definition of FWB was provided (35/74—47.3%), it aligned with the commonly accepted definition found in the literature, which states that FWB refers to blood that remains viable at room temperature for up to 24 h after collection.

Main outcomes

Mortality

A total of 11 [16, 17, 22, 32, 47, 53, 57, 59, 60, 69, 71] studies provided association measures comparing groups of patients who received either FWB, in addition to BCT or single blood components, against groups receiving solely BCT or single blood components (pRBCs or aPLTs) (Table 1). Specifically, 10 studies [17, 23, 32, 47, 53, 57, 59, 60, 69, 71] focused on early (< 24 h) or late (< 30 days) mortality (total sample size of 10,978 patients). These 10

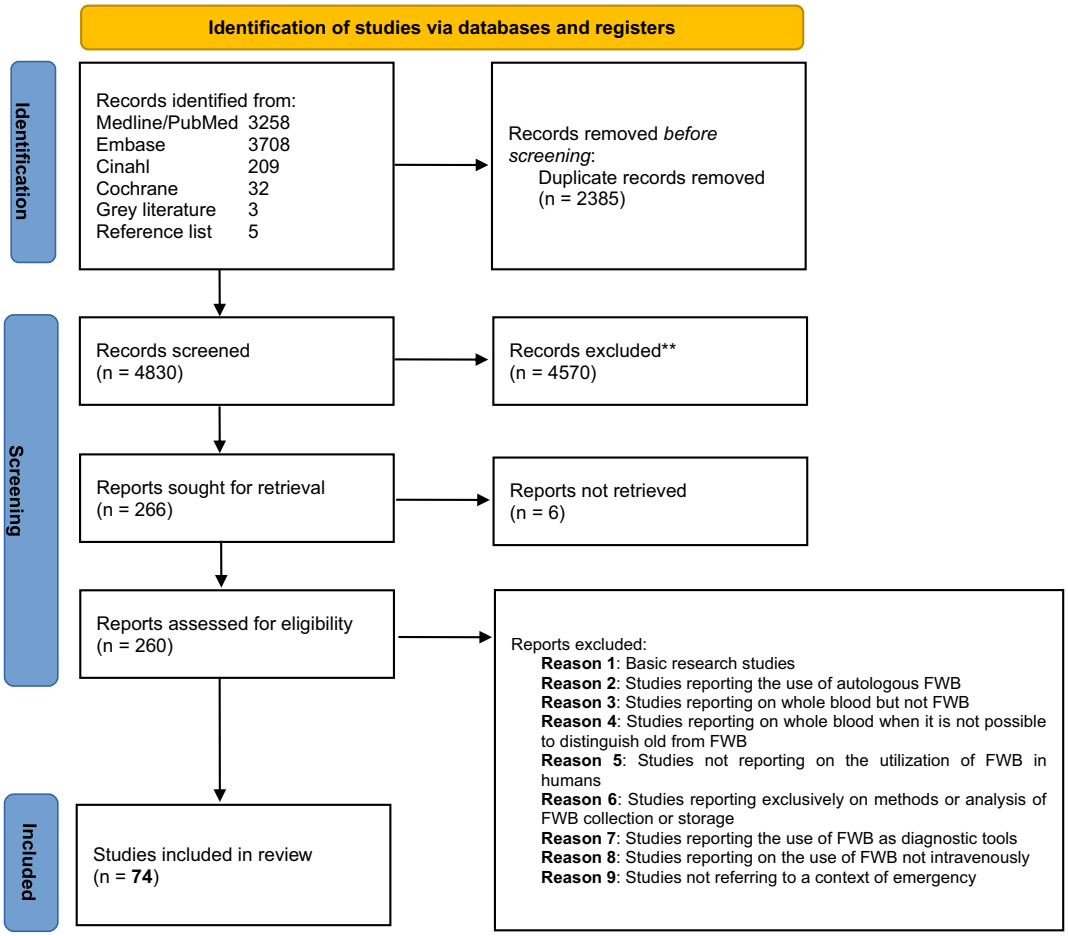

Fig. 1 PRISMA flowchart

Table 1 Association measures in relation to patients receiving FWB in adjunct to BCT versus patient receiving only BCT or single blood components

Article	Year	Sample size	Setting (civilian/ military)	Control group	Outcome description	Outcome (RR)	Adjustment for prognostic factors
Auten [22]	2014	61	Military	BCT*	Early Mortality (24 h)	0.81 (0.08–8.42)	Yes
					Coagulopathy	0.01 (0.00–0.18)	
					Transfusion reaction	0.17 (0.01–4.82)	
					Blood Clotting	0.87 (0.27–2.80)	
					ARDS*	0.73 (0.33–1.63)	
Chan [32]	2012	591	Military	pRBCs*	Late Mortality (30 days)	0.85 (0.56–1.29)	Not
					ALI*	1.06 (1.00–1.13)	
Gurney [47]	2021	1105	Military	BCT*	Early Mortality (6 h)	0.27 (0.13–0.58)	Yes
Ho [53]	2011	353	Civilian	BCT*	Late Mortality (30 days)	0.71 (0.31–1.62)	Yes
Kauvar [57]	2006	281	Military	BCT*	Mortality (timing not specified)	1.74 (0.59–4.57)	Not
Keneally [59]	2015	3937	Military	BCT*	Late Mortality (30 days)	1.25 (0.76–2.05)	Not
Lauby [60]	2021	3439	Military	BCT*	Mortality (timing not specified)	0.35 (0.05–2.5)	Not
Nessen [69]	2013	488	Military	BCT*	Late Mortality (30 days)	0.10 (0.02–0.53)	Yes
Perkins [71]	2011	369	Military	aPLTs*	Early Mortality 24 h	0.3 (0.08–1.04)	Yes
					Late Mortality (30 days)	0.72 (0.4–1.3)	
					ARDS*	2.90 (1.44–5.86)	
					MOF*	1.84 (0.79–4.31)	
					Embolic event	0.79 (0.37–1.71)	
Spinella [16]	2007	685	Military	pRBCs*	Transfusion reactions	1.15 (0.25–5.22)	–
Spinella [17]	2009	354	Military	BCT*	Early Mortality 24 h	0.3 (0.08–0.88)	Not
					Late Mortality (30 days)	0.08 (0.01–0 .56)	

*BCT, blood component therapy; ALI, acute lung injury; ARDS, acute respiratory distress syndrome; MOF, multiorgan failure; pRBC, packed Red Blood Cells; FFP, Fresh Frozen Plasma; aPLT, apheresis platelet

studies were included in our meta-analysis, yielding a pooled OR of 0.61 (95% CI: 0.38—0.98) with a medium degree of heterogeneity (I2 = 64.8%, p = 0.002) (Fig. 2). When restricting the analysis to the 8 studies [17, 23, 47, 53, 59, 60, 69, 71] that adjusted the analysis for possible confounders, the pooled OR was 0.47 (95% CI: 0.25—0.87) (Fig. 3).

When focusing on the 4 studies [23, 47, 53, 69] that used propensity score to balance differences between groups, the pooled OR was 0.35 (95%CI:0.15–0.82) (Supplementary Fig. 1). Additionally, subgroup analyses considering only studies using balanced BCT as the control therapy and those evaluating early or late mortality provided consistent results as well (Supplementary Figs. 2, 3).

Transfusion related complications

Ten original research studies [16, 22, 31, 36, 39–41, 48, 55, 70] reported about the occurrence of transfusion related complications, including graft-versus-host disease (GVDH) [55], transfusions reactions (allergy, febrile non-haemolytic reaction) [16, 22, 41], coagulopathy and haemolytic reaction [22, 55], transfusion transmitted diseases [16, 40, 48, 55], and transfusion-associated microchimerism [39]. In groups of patients receiving FWB in adjunct to BCT or single blood components, the occurrence of these transfusion related complications was extremely rare, except for pulmonary events, namely acute lung injury (ALI) and acute respiratory distress syndrome (ARDS) (Table 2).

In one study [39], 50% of patients receiving FWB developed transfusion-associated microchimerism, which refers to the presence of donor leukocytes in the recipient blood, constituting a minor (< 5%) population of allogeneic cells [90]. Nonetheless, this phenomenon seems to be common in injured patients receiving transfusions; indeed, the same study [40] found no significant difference in the prevalence of microchimerism between patients receiving FWB and those receiving pRBC alone.

Amount of FWB transfused

Five descriptive studies reported either the percentage of patients receiving FWB [29, 37, 41, 79] or the product utilization ratio of FWB transfused during specific military operations [85]. Apart from one study [79], the proportion of patients receiving FWB was notably low.

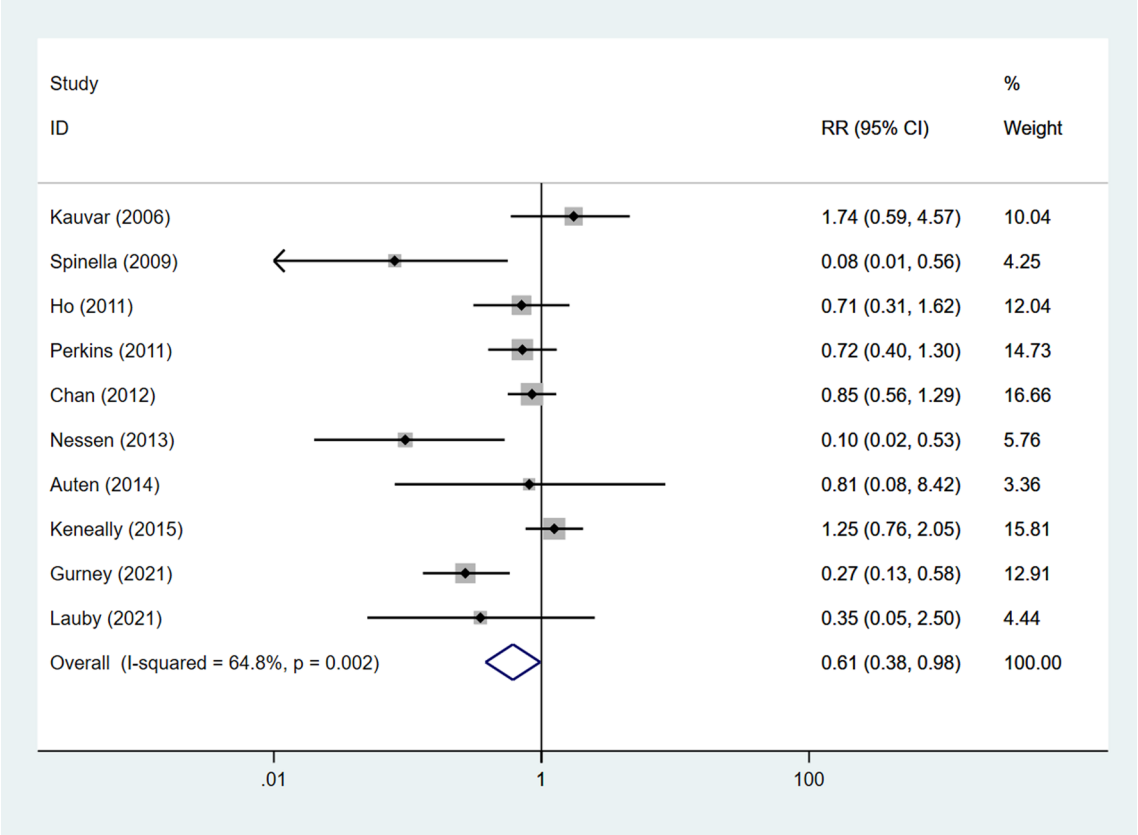

Fig. 2 Overall mortality after FWB administration

Of note, regardless of the context, authors underscored a consistent decrease in the utilization of FWB in parallel with the increase of the availability of blood products over time at hospital level. All studies emphasized that the use of FWB was influenced by the remote or resource constrained settings.

Discussion

Damage control resuscitation has undergone significant development over the past decades, culminating in a consensus on a balanced ratio of plasma, platelets, and pRBCs, along with strategies to prevent coagulopathy [91]. However, ensuring the availability of an appropriate quantity of blood components can be challenging in disasters and MCI settings. In this context, FWB has been proposed as a potential resuscitation option due to its balanced component composition and functionality, as well as absence of adverse effects commonly associated with stored blood, such as hypothermia, acidosis, haemodilution, and hypocalcaemia [91]. Nonetheless, despite numerous narrative reviews and retrospective studies advocating for FWB use, there is currently a scarcity of quantitative research on this subject. A plausible explanation for this could be that, at the time of this writing, FWB transfusion had been approved for routine use only by NATO [92] and not by the Food and Drug Administration or other civilian health agencies unless critical bleeding occurred in the absence of certified therapeutic solutions [15]. Furthermore, most of the studies informing current trauma management recommendations are conducted in high-income countries and not in MCI settings, thus making their findings hardly applicable to resource-limited environments [1]. This problem was also acknowledged by Naumann et al. [68] in their systematic review and meta-analysis on FWB administration. Interestingly, our review revealed a renewed interest in FWB utilization, especially since 2010. A growing understanding of the detrimental effects of excessive crystalloid administration before blood transfusion and/or extensive BCT, coupled with a higher number of terrorist attacks, could partially account for the increase of studies reporting on FWB transfusions [93–96]. Recently published guidelines on damage control resuscitation also emphasize the role of FWB in the treatment of haemorrhagic shock, reporting its mortality benefit as compared to BCT [91].

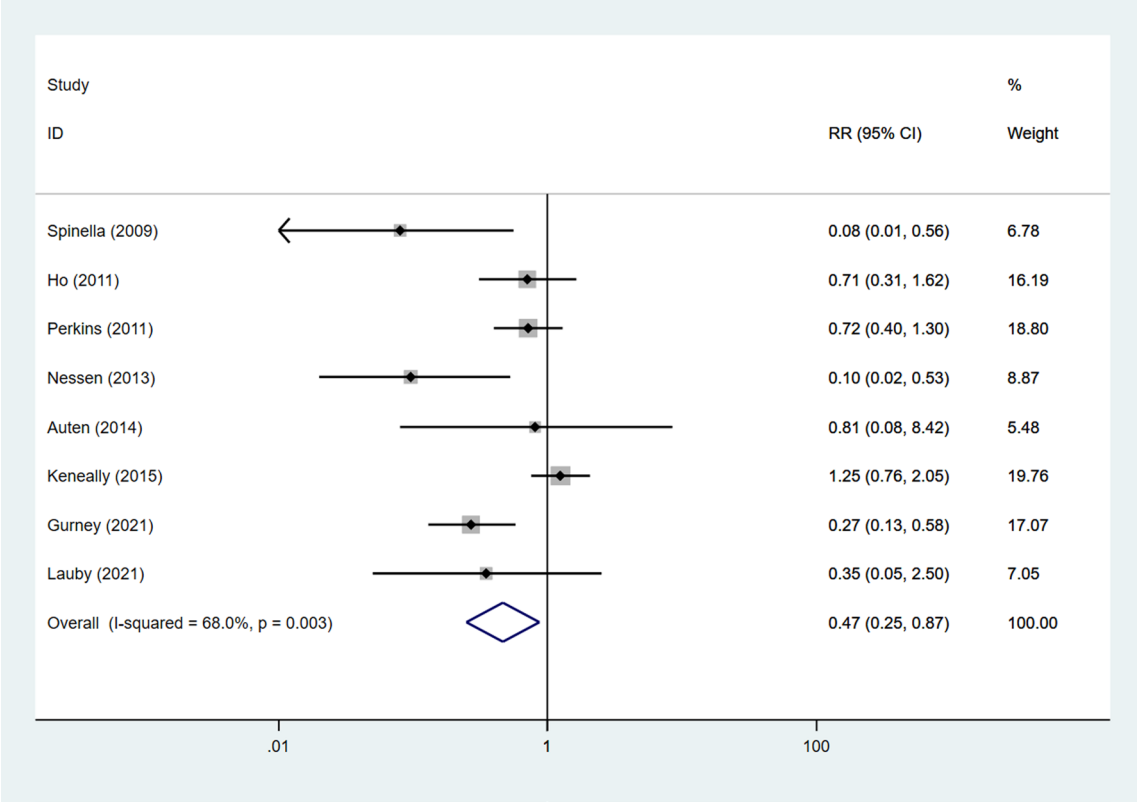

Fig. 3 Analysis restricted to studies that provided estimates adjusted for possible confounders

Similarly to Naumann et al. [68], despite the reduced risk of death found in the FWB group, the existing heterogeneity among considered studies makes it difficult to draw firm conclusions in terms of mortality outcomes between traumatic patients receiving FWB versus BCT. In contrast to Naumann et al. [68], who included crude effect estimates in their metanalysis, our analysis adjusted for confounders (e.g., ISS); this strengthens the protective effect observed. Moreover, an important risk reduction was also noted when accounting for potential biases between groups, including the likelihood of receiving FWB based on severity. Building on these results, we may conclude that the use of FWB does not pose an additional risk of death. Nonetheless, this mortality analysis is still difficult to interpret and hard to translate into a civilian context e.g., disasters and MCIs due to several factors: firstly, FWB was always given in conjunction with or following unsuccessful BCT, such as in cases either requiring more than ten units of pRBCs within a 24-h period or exhibiting significant shock or coagulopathy following optimal BCT [69]. Therefore, no comparison between FWB alone versus BCT was possible. Additionally, despite adjustments, the underlying condition of patients needing FWB for massive transfusion indicates that their status may have already been significantly compromised, thus lessening the efficacy of subsequent interventions and potentially skewing mortality comparisons [59, 64, 65]. Moreover, the predominance of military-focused studies introduces a notable bias towards younger, healthier male individuals. Such characteristics may not accurately reflect the broader civilian population typically encountered in disasters and mass emergency scenarios.

It is important to emphasize that the hesitancy in using FWB may also stem from concerns about infection transmission. Despite the inherent limitations of retrospective studies, our review suggests that the infectious risk remained notably low [36, 40, 48, 55]. However, it is important to contextualize this finding within the military setting, where individuals are generally assumed to be in good health and undergo infectious disease screening before deployment [97]. Conversely, in a civilian population lacking pre-screening protocols, the infectious risk is anticipated to be comparatively higher than in military contexts. Interestingly, advancements in rapid donor screening tests, including AB0 typing and detection of HIV, hepatitis B and C, malaria, and syphilis (RPR), with waiting times ranging from 60 s to 20 min [18], have significantly minimized the risk. Therefore, these tests could potentially enable the so called "the

Table 2 Descriptive statistics for adverse events reported in group of patients receiving FWB

Article	Year	Sample size (FWB group)	Setting	Adverse events	Occurrence of adverse events, %
Chan [31]	2012	148	Military	ALI*	18
Daban [36]	2012	15	Military	Transfusion reactions	0
				Transfusion transmitted disease	0
Dunne [39]	2008	6	Military	Transfusion-associated microchimerism	50
Erber [40]	1996	11	Civilian	Transfusion transmitted disease	0
Esnault [41]	2013	34	Military	Transfusion reaction	0
Hakre [48]	2011	761	Military	Transfusion transmitted disease (HCV*)	0.21
Katsura [55]	2020	28	Civilian	GVHD*	0
				Embolic Event	7
				ARDS*	4
				Hemolytic reaction	0
				AKI*	50
				Liver Failure	4
				Transfusion transmitted disease	0
Perkins [70]	2011	85	Military	ARDS*	18.8
				Embolic Event	10.6
				Any infection	25.9
				MOF*	13
Spinella [16]	2007	87	Military	Transfusion reactions	1.1
				ALI*	1.1

*AKI, acute kidney injury; ALI, acute lung injury; ARDS, acute respiratory distress syndrome; FWB, fresh whole blood; GVDH, graft-versus-host disease; HCV, hepatitis C virus; MOF, multiorgan failure syndrome

walking blood bank (WBB)" strategy also in disasters and MCIs [82, 98].

The WBB derives from the military environment and consists of pre-screened healthy soldiers serving as immediate FWB donors, allowing for the safe "transportation" of readily available blood products under optimal "storage conditions" until required. The Blood Desert Coalition has recently highlighted this concept in the context of civilian low-resource "blood deserts", emphasizing that while a WBB cannot replace a well-established blood banking system, it should be considered in emergency situations when laboratory-screened blood is unavailable, and the patient faces imminent risk of death or disability from haemorrhage [11]. Naturally, the logistical aspects related to the WBB need to be thoughtfully considered before it can be applied to civilian scenarios. Once again, the military setting facilitates logistics to some extent, both in terms of the immediate availability of donors (other military personnel) and the familiarity with the procedure, although in the absence of standardized protocols [99]. Establishing an emergency donor pool could offer a viable solution; however, it would need advertising campaigns, donor education with swift mobilization when required, screening for transmissible diseases and patient follow-up [100]. Secondly, standardized operating procedures for WBB blood donation and FWB transfusion should be in place; thus, a system for continuous education and training, including drills and simulations, is to be implemented to ensure operational effectiveness [101]. This is important given the infrequent incidence of MCIs.

Lastly, safety concerns remain regarding the transfusion of FWB that has not undergone complete viral testing (which typically takes 12–24 h after donation) or leucocyte reduction, which is a critical issue given the potential risks involved in using untested blood products in civilian settings. Current blood stocks in major cities, particularly in the absence of a readily accessible support system and donors, could be insufficient to meet the demands of multiple simultaneous severe bleeding casualties [7, 101–103]. Findings from over 35,000 simulations using a computerized model of a major trauma centre in the United Kingdom demonstrated that the transfusion chain would already be strained beyond capacity with just 20 patients needing blood simultaneously [104]. These logistical challenges are further compounded when it comes to plasma and platelet availability; therefore, applying the WBB could be strategic [98]. FWB transfusion is known to be a widespread practice in low-resource settings, where relatives or

bystanders are enlisted as WBB donors. However, standardized guidelines for this practice are currently lacking. Interestingly, despite the technical process of FWB collection was beyond the scope of this review, many of the papers retrieved reported detailed descriptions of how to organize WBB [23, 50, 68, 98–100, 105]. They could be a priceless asset for the potential implementation of a FWB collection and transfusion system in disaster preparedness.

Of note, the definition of FWB varied across studies. While in military practice FWB is defined as less than a 24-h of shelf-life, our results revealed that some civilian organizations extended this definition to 48 h [79]. This observation raises a question on the optimal storing time ensuring the most effective haemostatic benefit. Regrettably, our research did not yield studies addressing the in vivo haemostatic properties of blood after different storage times. This aspect is crucial, as the benefits of FWB are arguably influenced by the impact of temperature and storage on clotting factors and platelet activation [83].

It is worth mentioning that, within the studies reviewed, FWB was primarily administered in the hospital setting. Of note, given that severely injured individuals often die before reaching the hospital, and evacuation times to medical facilities can be prolonged, pre-hospital blood transfusions could potentially save lives. Nevertheless, managing the provision, storage, and oversight of blood products becomes even more daunting in this context. While SWB is gaining traction among prehospital emergency services [106–108], FWB remains a logistically intricate option [109].

Limitations

First, a significant limitation of this review was the inclusion of a limited number of prospective studies and the absence of randomized trials in our meta-analysis. Furthermore, all studies included in the meta-analysis involved patients receiving both FWB and BCT, precluding the comparison of the effects of FWB alone.

Second, most studies were conducted in military settings where the target population was mainly composed by pre-screened young healthy males. Therefore, results concerning the safety profile of FWB could have been different in other settings with higher risk or unscreened donors.

Third, authors acknowledge the common practice of FWB transfusion in low-resource settings, as well as by humanitarian aid organizations. However, original data regarding transfusion-related mortality and morbidity in these settings could not be retrieved in published literature, thus eluding capture by our search strategy.

Conclusions

The use of FWB presents as a promising alternative to BCT in managing disaster scenarios or instances of severe haemorrhagic shock accompanied by refractory coagulopathy. Notwithstanding reports from certain studies indicating comparable survival outcomes with negligible adverse effects, the existing body of evidence remains limited and lacking randomized controlled trials. Future studies are necessary to ascertain the efficacy of FWB and evaluate potential long-term adverse effects prior to considering FWB as a standard protocol in civilian trauma management. Studies focused on the feasibility of implementing the WBB concept in civilian context are also warranted.

Abbreviations

pRBCs	Packed red blood cells
FFP	Fresh frozen plasma
BCT	Balanced component therapy
PLT	Platelets
WB	Whole blood
MCIs	Mass casualty incidents
FWB	Fresh whole blood
WHO	World health organization
SWB	Stored whole blood
WBB	Walking blood bank

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s13031-024-00635-z.

Additional file 1.

Additional file 2.

Additional file 3.

Additional file 4.

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Author contributions

ARC conceived the present idea. ARC and MC supervised the screening and data extraction process, interpreted and discussed results, and drafted the manuscript. MR, GM, LP, DC and MB conducted the screening and data extraction process. FBA supervised the screening and data extraction process, performed the analysis, interpreted and discussed results. All coauthors reviewed and revised the paper and agreed to the published version of the manuscript.

Availability of data and materials

No datasets were generated or analysed during the current study.

Declartions

Competing interests

The authors declare no competing interests.

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